TITLE
Effect of plyometric strength training vs. knee-extensor strength training on shooting & 'Long Ball' passing accuracy in female footballers.

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DATE DEPOSITED
30 October 2017

Effect of plyometric strength training vs. knee-extensor strength training on shooting & 'Long Ball' passing accuracy in female footballers.

A Dissertation Presented to The Dept. of Sports, Health & Science, St Mary's Univeristy, Twickenham, TW1 4SX

In Partial Fulfillment of the Requirements for the Degree of Master of Strength and Conditioning

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By Alpha M. C. Cauwenbergh MSc, BSc - October, 2017

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ACKNOWLEDGEMENTS

Would like to thank and acknowledge the contribution of Swansea City Ladies football club and their Strength and Conditioning coach Jack Spillets in the assisting and organisation of both testing day protocols and monitoring aspects of the training interventions. Finally, thank you Dr. Giuseppe Cimadoro for your astute guidance towards the latter phase of the project.

PREFACE

The study was designed in an attempt to answer whether a strength training program of either lower body plyometric strength training or isolated knee extension strength training performed twice a week for 6 weeks would significantly effect a female footballers accuracy when striking a football for a Long ball pass and or shot towards goal, and if so which one more? This research paper attempted to produce a significant effect on said accuracy by changing the relationship between the force at which a ball is struck and the accuracy of the strike. Done by, increasing the degree of kicking power available to the athlete at the submaximal, and more accurate ranges of ball striking velocity. The paper sought to highlight important issues and provide the strength and conditioning community with the meaningful first steps towards tackling them.

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ABSTRACT

Women's football has discrepancies in passing and shooting performance in comparison with the men's game. The aim, improve this by comparing the effect Plyometric Training (PT) and leg-extension Strength Training (LEST) has on Long Ball (LBP) passing (LBP) and Shooting Accuracy (SA). 18 semi-pro female footballers aged 22yrs ± 3.68yrs, height 1.72m ± 0.05m, weight 61.01kg ± 12.46kg divided randomly into three groups, a Knee Extension Group (KEG), Plyometric Group (PG) and Control Group (CG). The LBP and SA of their preferred leg, using a bespoke 356-Soccer Shooting Test (356-SST) was tested. Re-tested after a 6-week PT and LEST intervention to increase power in knee extensors. A T-test, One-way ANOVA Post-Hoc and an Inter-Class Correlation (ICC) test of reliability was performed. Results showed an increase in Leg extensor strength, 58.25kg ± 14.3kg to 64.92kg ± 16.4kg ($p= 0.00$) for the KEG, and no significant ($p<0.05$) increase in power scores for the PG. A significant variance in the increased mean LBP of the KEG when compared to the CG ($p= 0.010$). LBP of the KEG increasing, 6.5AccP ± 6.3AccP to 11.7AccP ± 3.7AccP. No other significant variance in mean was found comparing the PG against the CG or KEG, for LBP or SA. LBP and SA procedures had an ICC coefficient of 0.693 and 0.516. Pre and post-test passing coefficient of variation was 15% and 46%, and for shooting 49% and 59%. It was inconclusive if improved power of the knee extensors is related to LBP and SA in semi-pro female footballers, furthermore SA appears more robust to improvements in power than LBP.

***Key words*:** kicking, velocity, performance, power, soccer

INTRODUCTION

Research into the activity profile of women's football suggested significant differences between their male counter parts. A Study of male and female players playing in the Champions League [6], found no gender differences for technical activities such as the amount of touches of the ball, the time in possession of the ball or the grand total number of duels won during both halves and the entire match (ES: 0.1 to 0.3). Although, female players did lose possession of the ball more often, at the $p < 0.05$ significance level. As well, a lower pass completion rate than their male counterparts - during both halves of the match, and the entirety of the game (ES: 0.5 to 0.9). Research comparing gender differences in the activity profiles of footballers is very scarce, and a larger body of work is needed to further corroborate the above findings. Another similar study by [4] looking specifically at playing behaviour found that, female players used more longer passes than men, instead of shorter skills such as dribbling or short-range passes. The study also stated that males have greater success shooting/scoring from longer distances, indicating a mean distance for successful shots on goal being 13.1m and 10.8m for women, it attributed this to a suggested greater level of muscular strength in male players. Research showing male superiority in certain physical activities [12,9,41,39,40], Fall in line with attributing this gender difference to a physical advantages afforded to their male counterparts. However, stating that it is the result of muscular strength without much specific evidence could be a mistake - other technical aspects could be at play.

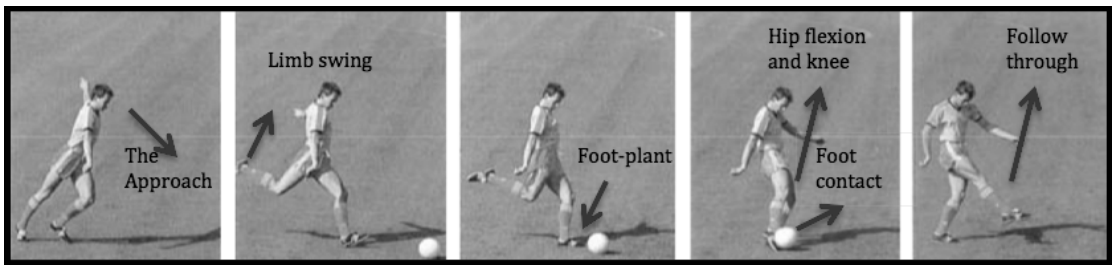
Shooting is an important skill in football, but literature on the gender differences in the accuracy of said skill or any other such as heading the ball towards goal appears almost non-existent. This, and the suggestion from what research is available that technical differences in passing and longer range shooting (beyond 16m i.e. the goal area) behaviour and proficiency stem from gender based physiological differences make it a fascinating topic to consider. The factors that typically affect the execution of sports skills are talent, number of hours of practice e.g. Malcolm Gladwell's 10,000 hours theory, physiological qualities like maximal strength and power for propelling objects greater

distances [47] balance and unilateral proficiency [44] and of course physical fatigue - neurological or metabolic [28]. All can affect the successful completion of a pass or accuracy of a shot. Which factors are most responsible for the suggested discrepancy in pass completion and longer range shooting proficiency requires investigation.

Researching the affect all of the aforementioned factors have on passing and SA is beyond the scope of this paper. Therefore, to focus the research parameters and produce data relevant to the original questions posed; do physical gender differences affect shooting and passing proficiency? Moreover, which one(s)? Those two technical skills were the focus of the research. Furthermore, women not only play more longer passes during match play, they are also less skilled at doing so [4], elevating the importance of the skill's improvement further. The findings of this research could better inform the strength and conditioning practice in training female footballers. In addition, the research built from it's foundations could help close the gap between the professional men's and women's games technical standard and in a wider commercial context too.

The biomechanical determinants of kicking a ball with the aim of applying high velocities to it are summerised as; Quality of foot to ball contact effects final speed, path and spin of the ball. Powerful kicks are achieved through a high foot velocity and coefficient of restitution. Furthermore, the soccer kick is achieved through segmental and joint rotations in multiple planes and via the proximal-to-distal sequence of segmental angular velocities until ball impact. Finally, ball speed values during the maximum instep kick range from 18 $m \cdot s^{-1}$ to 35 $m \cdot s^{-1}$ depending on various factors, such as skill level, age, approach angle and limb dominance. [21] [22] [25] [26] [33].

Figure 1. Illustration of the typical high velocity ball striking technique in football.



http://fhendersonbiomechanicsofinstepdrive.blogspot.co.uk/2015/06/what-are-optimal-biomechanics-of-instep.html

If powerful kicks are achieved via high foot velocities - which come primarily from a powerful knee extensor action (among other, balance, joint and muscle related factors), the movement of which is provided by the concentric contraction of the quadriceps [24,26,27,34,22]. How best to elicit an increase in a female footballer's quadriceps contractile becomes the next consideration.

To discover if an increase in power capacity, would result in an increase in SA and LBP, their relationship must be assessed. The relationship between power and accuracy within the parameters of those specific sport skills ('more' power = less accuracy) is touched upon in [17] which although based on throwing and not kicking illustrates this relationship, past a certain 'ideal' point (75 % to 85 %) the more power applied into the action was at the sacrifice of accuracy. This concept is indirectly touched upon further in [22], they refer to [26] and [44] papers that state that when subjects where kicking a ball with the aim of maximizing accuracy, the ball, joint and angular velocities were reduced in comparison with kicking for maximum power. Therefore, could this implies that when female athletes are shooting and passing from greater relative distances, they are being forced to apply more power (beyond the suggested 75 % to 85 % ideal) then their male counterparts. Therefore, subconsciously sacrificing some of their accuracy to allow the ball to cover the distance at the required velocity i.e. fast enough to beat a goal keeper/fast enough to beat a defensive line. This power and accuracy relationship, though not having vast amounts of literature

behind it - anecdotally is something experienced by all professional sports people and is intuitively meaningful. Thusly, female footballers with a greater reservoir of kicking power available to them over the same distances, would be afforded the ability to adjust ball-striking strategy. I.e. bringing the power used in the execution of the kicking skill down closer and into the 75 % to 85 %, 'ideal' (in terms of accuracy) suggested by [17]. Potentially reducing the discrepancy found between genders in pass completion [6] and longer range shooting proficiency [4].

The methods of increasing power in the knee extensors is the next logical focal point. It has been well reported that strength training can increase this power. One such method being plyometric training – with multiple studies reporting a significant increase in power output of the lower limb musculature and quadriceps specifically. [5] Study reported that in a neurological test performed at two different knee flexion angles, the rate of torque development and Impulse was higher during the time interval 0 ms to 50 ms, 308.7 $m^2 \cdot kg \cdot s^{-1}$ (-1) (95% CI: 28.8 $m^2 \cdot kg \cdot s^{-1}$ to 588.6 $m^2 \cdot kg \cdot s^{-1}$ (-1), P = 0.033) and 0.32 $m^2 \cdot kg \cdot s^{-1}$ (95% CI: 0.05 $m^2 \cdot kg \cdot s^{-1}$ to 0.60 $m^2 \cdot kg \cdot s^{-1}$, P = 0.026), respectively. There was also an enhanced neural drive to the quadriceps muscle. This was also expressed practically by an increase in squat jump and counter movement jump performance. However, the subjects used were not female footballers. Perhaps there would be a different degree of improvement in such a context, due to not having the time of facilities available to use this studies methodology. [7] Research paper, used both subjects of a more elite athletic nature and ones of the female gender, and it's findings corroborated the large body of literature that indicates the positive effect plyometric exercise can have on knee extensor power. They reported that the Rate of Force Development (RFD) at 100ms and 180ms were greater post intervention (3920.95$m \cdot kg \cdot s^{-1}$ ± 1680.92$m \cdot kg \cdot s^{-1}$ to 4362.69$m \cdot kg \cdot s^{-1}$ ± 1633.53 $m \cdot kg \cdot s^{-1}$, P value of 0.385 and 2929.10$m \cdot kg \cdot s^{-1}$ ± 1333.58$m \cdot kg \cdot s^{-1}$ to 3372.37$m \cdot kg \cdot s^{-1}$ ± 1039.62$m \cdot kg \cdot s^{-1}$, P value of 0.295). Although not significant at the 95% CI, these findings combined with the larger body of findings of positive significance, [33] (which used the vertical jump - a strong knee extension movement as a testing protocol) found

a significant positive effect ($p < 0.05$) suggests an appropriateness of this modality for our research study. It should be noted though that in such a compound movement, other muscles also plays a role in producing power within that movement. [7] Finds that the calves too play a significant role in dynamic explosive jumping.

PT intervention would also be appropriate in this research project in assessing the resulting physical adaptation's effects on passing and SA. [35] Study's results showed that combining heavy strength training and PT increased peak angular velocity of the knee during kicking (+13.6%), increased percentage of myosin heavy-chain (MHC) type IIa (+8.4%) in footballers. However unlike the previously mentioned study this was performed on male participants not female. So the degree to which these improvements would be present in female players is not certain, due to the male gender's superior propensity for hypertrophy as indicated by males at the same body weight as females having higher fat-free body mass. But, literature suggesting that there is no difference in the quality (strength & architecture) of male or female muscle [2] would indicate that significant improvement following the same protocol would be expected in female participants. This is further backed up by [36]. The findings of [34] that heavy strength training improves the expression of lower limb power is somewhat corroborated by [9] Whose study show there to be a significant increase in voluntary peak power out put ($p<0.05$), furthermore Both typical force-velocity relationships and mechanical parabolic curves between power and velocity increased after the strength-training program. In their study, the back squat was the training intervention used. Point of consideration is that this study used junior footballers aged 17 yrs ± 0.5 yrs, which were untrained in resistance training previously to this study. This gives rise to the question of what level of subject (female footballer) would this proposed study see greatest results in, and have the greatest practical benefit to their sporting and training practices? This question will be returned too later.

[39] Concluded based on its findings that low impact PT could improve kicking distance in adolescent female players ($p < 0.001$). The study methodology was relatively robust, however I question its definition of low impact PT, and thus the conclusion drawn. PT intensity beyond the nature of the exercise difficulty and stress placed on the Stretch Shortening Cycle (SHC) is relative to the subjects training/injury history and anthropometry i.e. body weight and height. [47] Backs up this notion by finding a positive correlation between anthropometrics and various physiological characteristics in adolescent soccer players e.g. height being significantly ($p < 0.05$) correlated with vertical jump height ($r = 0.36$). Therefore, it's unclear if all subjects partook in low impact PT. Careful exercise selection in this study will be important in eliciting the desired response.

[38] And [37] the latter, which focused on how creatine supplementation would influence, the effect PT has on maximal intensity exercise and endurance in female footballers. Both papers found that PT improved jump performance in both cohorts. The thoughts [38] raised for future research and this current study are that; its duration was six weeks, the football season is longer - how would genders respond over a longer duration of continuous or intermittent PT, e.g. if periodised and cycled back to on a bimonthly basis. Would the reported gender related different ankle, knee and hip biomechanics [43] of jump performance have an influence in their response to it over the long-term? Especially when combined with the accumulative stresses on said joint kinematics from competitive match play.

There are some studies like, [32] and [30] that although find significant effects of PT on physiological characteristics, use subjects that are random, non-elite (because their too young or two old, or lacking in ability) or non-footballers - making it difficult to infer appropriateness to this study, or professional sport. It is becoming clear that careful subject selection beyond being female and a footballer is an important point of consideration. For example what effects could be expected from players of different levels and thus what level of player is most appropriate for this study.

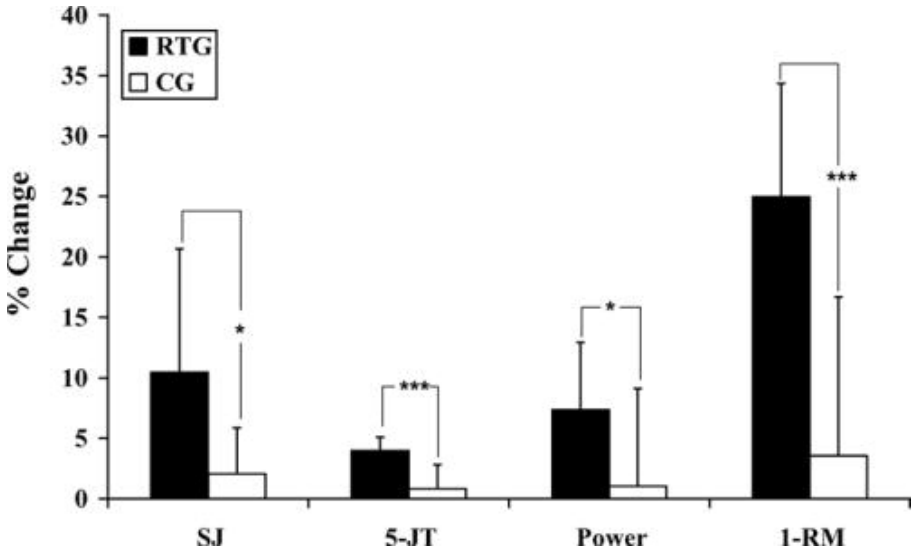
Several studies have been found to help answer said question. [11] Study on the strength and jump biomechanics of elite and recreational female youth soccer players; found that players of both levels had similar levels of strength and biomechanical patterns. Suggesting perhaps that any potential significant findings in this research project could be applied and beneficial for amateur to professional level players, in terms of the degree to which there lower body strength and power can be improved, and positively effect there LBP and SA. [47] Findings on the physical performance of elite female players at different ages groups, show a large improvements in all capacities tested occur from 12yrs of age until approximately 16yrs of age. After which any improvement level off and are marginal in comparison. This suggests that the desired age of the subjects for this research project would be 18+, as this would reduce interference from natural physical progressions in strength and power associated with age maturation through puberty and into adulthood. [23] Sought to evaluate the explosive strength of 7 as side female players versus their 11 aside counterparts. They saw no difference in explosive power as a function of time over the course of a match, however there was a significant difference in Squat Jump (SJ), Counter Movement Jump (CMJ) and the elastic recoil index between the two groups of players. The 7 aside players being superior in all afore mentioned capacities. This is meaningful for this study because it suggests that if seeking to significantly improve female football players kicking power and thus technical accuracy via increasing maximal knee extension strength and plyometric strength, the 11 aside game would be where one would obtain more meaningful gains and technical benefits following the specific training intervention.

For a research paper more relevant and applicable to professional football, another form of leg-extensor strength training had to be considered. As in a professional sporting setting, there may be athletes unable to perform explosive high impact exercises due to injury to one of more of the joints and or muscles involved. Due to the ball kicking specificity of the leg-extension exercise, and

scientific evidence of the efficacy of resistance strength training at around 60-80% of 1rep max with 'fast' concentric actions [14,15,21,20,1]. The resistance machine based leg-extension strength training was selected as a training modality to increase leg-extensor power capacity. The study is aware that small differences in methodology between this paper and those cited e.g. duration, type of contractions utilised, subjects age, physical level, training history and equipment used may result in slightly different results. However, feel the scientific foundation for this rational has merit.

[35] And [9] research found significant effects of (ST) ($p<0.05$) on power capacity of the knee extensors. The former stating results of increased peak angular velocity of the knee during kicking (+13.6 %), increased percentage of myosin heavy-chain (MHC) type IIa (+8.4 %) in footballers. However, this was achieved by combining PT in the intervention. The latter showing there to be a significant increase in voluntary peak power output, figure 2 is a graph from said study illustrating the percentage increase in comparison to the control group;

Figure 2. Resistance training group vs. control group.



Although, it did use the back squat - a more hip dominant exercise to condition the quadriceps as opposed to an isolated knee dominant one i.e. the leg extension. By the rationality of exercise to sport skill specificity training, the more knee dominant movement of kicking a ball

could perhaps be better enhanced by leg-extension exercise. The other aspect to consider is that the test subjects were under eighteen years of age with little training experience in the back squat. In mature footballers with experience of the exercise, there is the possibility of the effects being elevated above the level of statistical significance. This reiterates the issue of choosing subjects appropriately to maximise chances of meaningful results.

On that note of subject selection, football teams usually have players that range from youth U18 right up to those in their late thirties, and on occasion an outlier who's approaching his or her middle ages. [16] And [12] although lacking other football specific methodological similarities to this paper, does suggest that strength training can improve knee extensor strength and power up until old age, the latter presenting this in female subjects.

Within the leg-extension resistance training modality, there is also a question of isokinetics and how to best to produce the sport specific response in knee extensor strength the paper is looking for. This research project looked for methods beyond the accepted and most commonly used Strength and Conditioning (S&C) practice. An interesting study on if training with an accentuated load on the eccentric contraction would produce greater strength gains in concentric contraction, compared to equal load on both parts of flexion and extension of the knee [19] It didn't find any significant effects for using an accentuated load (of 40 % more) on the eccentric action. Even if this study had found a significant effect, comparing its findings to others of it's type becomes a moot point when one considers that the equipment required for such a training modality is unavailable for this project.

To the best knowledge of this researcher, studies directly assessing the effects of the PT and or knee extensor ST on passing and or SA are non-existent, let alone those in reference to female footballers. Most focus on the effects on kicking power/velocity, and not the accuracy of said ball

striking as a result of this change in kicking velocity. No study was found that alluded to short or more relevantly LBP accuracy as an extension of kicking velocity either. The large literature review of the role of strength and conditioning on enhancing kicking velocity in football by [49] backed up that, kicking power can be improved by S&C programs added to regular football training, especially at the lower level of the sport. Furthermore it gave special mention to how potentially valuable PT could be for achieving said effect.

The review of the literature around these subjects, the questions they gave rise to, and how to go about answering them were used to inform the structure of this research paper. The overall research aim and individual research objectives are to identify the effect of two different types of strength training has on SA and LBP accuracy. Evaluate critically what these effects (if any) were and how they were elicited and what they infer. Explore the significance of these effects/inferences in terms of achieving sporting excellence in women's football. Finally, formulate recommendations for Strength and Conditioning Coaches at women's football clubs.

I hypothesis that both lower body plyometric strength training and isolated knee extension strength training will improve SA and LBP accuracy.

METHODS

Experimental Approach to the Problem

As a first step on a wider scientific journey was to assess how the accuracy of shooting (beyond 16m from goal) and passing the ball (over 30m) with the preferred leg, will be affected by increasing the knee extensor power afforded to the female athletes - These distances were selected because they require a closer to maximum percentage of the kicking velocity a player can apply to the ball. Thusly a PT and leg-extensor strength training protocol was used to increase power of the quadriceps of the subjects, PT performance assessed by vertical jump scores and leg-extensor

strength performance measured by maximum load lifted at the selected repetition range. The Aim, to improve their maximum capacity to affect velocity on a ball, and therefore allowing the subjects to strike a ball post intervention, over the same distance as pre-intervention while using a lower percentage of their maximum power capacity. Thus theoretically allowing for a more measured, controlled and accurate LBP and Shot towards goal.

Participants were: players aged over 18yrs old (22yrs ± 3.68yrs), have been injury free for 2 months before start of trial. This study was approved by the St Mary's University ethics board and all subjects were explained the benefits and risks before signing and returning a consent form approved by St Mary's University. In addition subjects completed a Physical Activity Readiness Questionnaire (PAR-Q) prior to commencing the first testing session. Recruitment was from Swansea City Ladies Football Club, a semi professional standard club.

In total the PG and KEG participants were required to commit approximately 7hrs and 20mins to the study, 1hr and 20min total for the two testing sessions, and 6 hours over a 6 week period for the training interventions. The CG were only needed to commit 1hr and 20mins total for the two testing sessions.

All testing and plyometric training sessions were performed at Swansea City Academy, Beaufort road, Landore, Swansea, SA6 8AX. With gym based knee extension training having occurred at individual participant's local gyms. The gym itself was ascertained from the participant before the start of the study, and the equipment within the facility reviewed by an exercise professional for suitability.

All materials and equipment's used in the study are the intellectual property of third parties such as major sporting equipment brands and Camera makers. (Coloured Cones, Nikon D5000, Open Reel

Surveyors Tape, hama Alpha 60 camera stand, PVC Insulation Tape, size 5 MITRE footballs, and FSL Jump Mat) The 356-Soccer Shooting Test (356-SST) [36].

Subjects

This is a quantitative study on analysing pre and post intervention testing data. To detect an effect size ($d = 0.8$), with a power of 0.95, assuming an alpha-level of 0.05, the total number of participants required in the study is 28. However, I am limited to recruiting a maximum of 12 participants for the intervention cohorts and 6 for the control cohort, this being due to the nature of a single football club squad size, and the availability of these athletes and training resources. Sample size estimations were performed using G*Power (version 3.1).

The test subjects consisted of 5 players (lost the 6th through an injury on the day before testing) in the Plyometric Strength Training cohort (PG) – (2 goalkeeper, 2 midfielder, and 1 forward). They had 5 years of experience in 11 aside football training on average 1 & half hours a week, playing a match weekly. 6 players in the Isolated Knee Extension strength training cohort (KEG) - (2 goalkeepers, 1 center back, 1 midfielder, and 2 forwards) also with 5 years of experience in 11 aside football - training on average 1 & a half hours a week, playing a match weekly. A control group (CG) of 6 players performed the normal football training regime, (2 center backs, 2 full backs, and 2 midfielders). Also having 5 years of experience 11 aside football - training on average 1 & a half hours a week and playing a match weekly. Prior to testing the subjects were required to complete a Medical History Form and a Participant Consent Form. Based on the information submitted on the Medical History Form, any subjects with long or short-term illnesses or injuries were replaced where possible by healthy, uninjured subjects. Of the 18 subjects fitting the criteria 12 were separated evenly and without preference into the plyometric and knee extension groups. The 12 considered first team regulars were placed in the control group due to their greater match

commitments, and the potential effect the training intervention could have on their weekly recovery cycle and thus match performance.

Procedures

The experimental procedure consisted of two main tests (one for shooting & one for passing) that utilise a bespoke version of the 356-Soccer Shooting Test (356-SST) [35].

Figure 3. The 356-Soccer Shooting Test (356-SST).

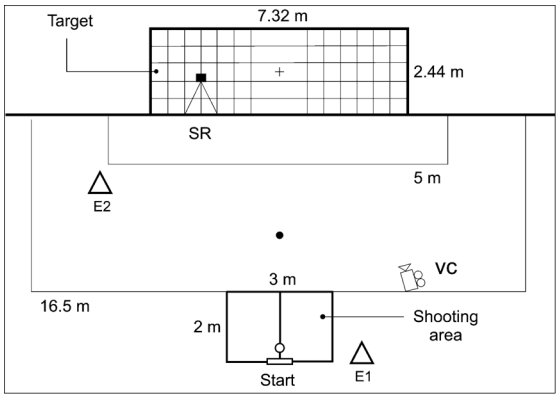


Figure 4. The 356-Soccer Shooting Test (356-SST) accuracy point scoring system.

	1	2	3	4	5	6
A	3.56	3.10	2.65	2.21	1.79	1.41
B	3.45	2.98	2.51	2.04	1.58	1.13
C	3.42	2.94	2.46	1.98	1.50	1.02
D	3.45	2.98	2.51	2.04	1.58	1.13
E	3.56	3.10	2.65	2.21	1.79	1.41

Scoring zones and determined distances (m) from the centre of each particular scoring zone to the goal-centre (cross sign).

Figure 5. Five square scoring grid for LBP test (5AccP at center and 1AccP at outer square).

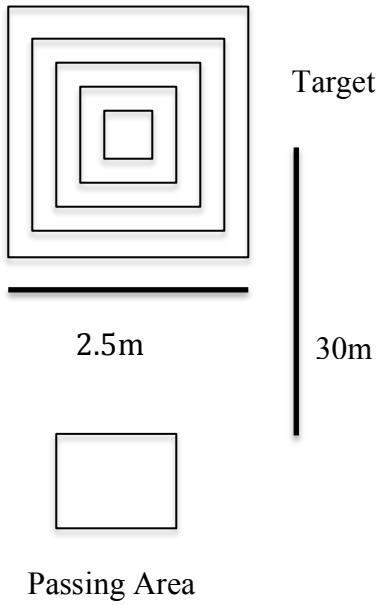


Figure 3 represents the layout of the 356-SST. Note: SR = sports radar gun (was not used in this study); E1/E2 = examiner 1/examiner 2; VC = video camera; cross sign (+) = goal midpoint; Figure 3 depicts the setting for shooting with the preferred leg. Figure 4 shows points are allocated to the different scoring zones (ball landing point), performance is reviewed on the video recordings after the fact. The 'Long ball' passing variation will be performed with the same template, but with the starting position being a further 30m away from a five square grid (each square of the grid 50cm in from the previous) of cones placed on the floor as the target (Figure 5). Getting the ball into the center square of the five square grid gains the most accuracy points. In both shooting and LBP tests, a subjects accuracy points (AccP) are the sum total of all 10 attempts.

This test requires performance with both the preferable leg and non-preferable leg, however time constraints meant that only the preferred leg data was collected. There was 6 weeks between the initial test and re-test. Measurements were performed on a 4G artificial grass football pitch. The data was collected over a period of constantly stable and dry weather conditions. Participants came to the testing pitch in groups of three, and refrained from exhausting physical activities 1 day before testing. This to minimise the effects of delayed onset muscle soreness, and other similar sources of

variation. All participants were equipped with their standard football training clothing and footwear. A 20-min standardised warm-up consisting of running tasks, stretching exercises and ball technique drills preceded both main tests (Table 1). To reduce the learning effect, players were given two free

opportunities with their preferred leg to habituate themselves with the testing protocol before recording sequences. Both main trials required participants to complete a total number of 10 attempts.

Table 1. Warm up routine.

Exercise	Set	Intensity (%)
Jog 100m	1	60%
Dynamic hamstrings stretch 15m	1	60%
Dynamic hip flexor stretch 15m	1	60%
Dynamic quadriceps stretch 15m	1	60%
Dynamic glutes stretch 15m	1	60%
Open Gate Jog 15m	1	70%
Close Gate Jog 15m	1	70%
Lateral skips 15m	1	70%
A Skips 15m	1	80%
B Skips 15m	1	80%
C Skips 15m	1	80%
Sprints 30m	3	80%, 90%, 100%
Dribble and pass 20m	2	100%

In-between the pre and post tests the subjects were put through two different training interventions as previously described. The training protocols were as follows; during the intervention period, the team trained twice a week. On Wednesday and Friday, the sessions lasted approximately 120 minutes each. At each training session, the Plyometric Group (PG), Knee Extension Group (KEG),

and Control Group (CG) performed the warm-up, technical and tactical program designed by the team's football coach together. Training games and competitive matches on Sundays were also carried out together. The physical conditioning program differed for the 3 groups.

Control Group Training: During the 6 week intervention period, continued with its regular football physical conditioning program after the warm-up on Wednesdays and Fridays. These, consisted of running based metabolic conditioning drills merged into technical skill drills. For example, repeated sprints that have passing or shooting elements at their beginning, middle, or end (table 2). The program included the previously stated metabolic conditioning session followed by tactical training and small-sided games. The session was completed with a cool down and stretching of all major muscles used (table 3), led by the clubs S&C coach. Furthermore, some players followed their own gym-based strength training regimes outside of training. Any that usually perform exercise protocols similar to those used in our training intervention were asked to cease them in favour of other non-conflicting ones, meaning no plyometrics, or knee extensor resistance training. hamstrings, glutes, calfs, upper body and or core exercises were permitted.

Table 2. Football training metabolic conditioning drills

Exercise	Set	Intensity (%)
20m sprint with ball, pass, shoot 1st time	4	100%
20m zigzag sprint, receive, shoot	4	100%
1min Repeated 10m sprint & pass (2 touch)	1	100%
1min Repeated 10m sprint & pass (1 touch)	1	100%

Table 3. Cool down routine.

Exercise	Set	Intensity (%)/Time (sec)
200m Jog	1	50%
Static calf stretch	1	30sec
Static hamstrings stretch	1	30sec
Static hip flexor stretch	1	30sec
Static glutes stretch	1	30sec
Static quadriceps stretch	1	30sec
Static lumbar stretch	1	30sec

PG group performed a plyometric program to improve power capacity in knee-extensors; in addition to the aforementioned metabolic conditioning routine, they performed as part of normal football training. Before commencing said intervention, base lower body power capacity was assessed via a counter movement jump test. With a re-test occurring at the end of the intervention period.

Plyometric Training Group: A trained S&C coach gave specific instructions and demonstrations of each plyometric exercise before the first session. The plyometric training took place after the warm-up, 2 days a week for 6 weeks (12 sessions distributed on Wednesday and Friday, with both supervised by the same coach. Each plyometric session will take 20-30minutes to perform, and the training regime was based on 2 different exercises, always coming after exercises specific warm up protocol:

Table 4. Plyometric training intervention program.

Exercise	Reps	Set	Rest Time (sec)
Wednesday			
Warm up set			
Jumps over hurdles of 30cm height spaced apart at 45cm intervals	5	4	30
Working sets			
Bounds for height	12	2	60
Bounds for distance	12	2	60
Friday			
Warm up set			
Bilateral Counter Movement Jumps (with hand on hips)	5	4	45
Working sets			
Unilateral DJ off an unfolded Rebook step at level 1 into unilateral Counter Movement Jump (hands free)	5	2	120
Bilateral DJ off an unfolded rebook step at level 3, into bilateral Counter Movement Jump (hands free)	8	2	90

Training sessions were carried out on an artificial 4G-grass surface. After 3 weeks, the number of jumps increased via an extra set on each working set exercise on Wednesday and Friday. After 6 weeks, the total number of jumps was 795. Intensity in terms of height/length and speed was always maximal. During the jumps over hurdles, Bounds and DJ, subjects were instructed to jump from their preferred chosen knee flexion angle for achieving the optimal jumping height. Technical proficiency of jumps was monitored throughout, quantity was sacrificed for quality wherever necessary, and reps completed were noted. In all the exercises, subjects were asked to minimize ground contact.

The same football training principles applied for the KEG, with of course them performing knee extension exercises as opposed to plyometric exercises. Their base level knee extensor strength was self reported (maximum load lifted for 10 repetitions) at the start of the training protocol, and then also at it's end.

Knee Extension Group; Individuals had a trained S&C coach give specific instructions and demonstrate each of the exercises before the first session. The training session was self reported, taking place at the subjects local gym either before or after football training sessions, 2 days a week for 6 weeks (12 sessions performed in total) every Wednesday and Friday. Each KEG session took 20-30min minutes to perform, and the training regimen was based on 1 exercise, the seated leg extension. It followed a flat pyramid structure (weight increases with each set while repetitions remain that same) of 3 warm up sets and then 3 working sets of 10 reps, and 2.30min rest between sets (performed on both legs). Furthermore, reps were performed with emphasis being placed on a quick concentric contraction phase, and a slower controlled eccentric phase as per the UKSCA strength training protocols. Cool down protocols were also followed, consisting of stretching the quadriceps muscles. Subjects made notes of completed reps and loads lifted for each session.

During the intervention period of 6 weeks, PG, KEG, and CG players will not be allowed to perform any other strength training that would impact the results. All subjects completed the 6 weeks of the training intervention once started, with only one of the proposed subjects being injured the day before the first testing session. There were no other available players that matched the subject selection criteria to use in replacement, thus the PG was reduced to 5 from 6.

Statistical Analysis

An F-Test was performed on the data set, in the form of an One-Way ANOVA Post-Hoc Analysis to determine post intervention data significance. Significance was set at $p < 0.05$. Furthermore, a Paired Samples T-Tests was performed to analyse changes in squat jump scores of the PG and the Leg-extension strength in the KEG. Significance was set at $p < 0.05$. Finally, a test of reliability was performed on the independent variable data set.

RESULTS

Description, Analysis and Synthesis

Results showed a significant increase in Leg extensor strength, from 58.25±14.3kg to 64.92±16.4kg ($p= 0.00$) for the KEG, and no significant ($p<0.05$) increase in power scores for the PG (Table 6). There was a significant variance in the mean LBP accuracy of the KEG when compared to the CG Post-Hoc ($p= 0.010$) (Table 7). However no other significant variance in mean was found Post-Hoc when comparing the PG with the CG or KEG and visa versa for either LBP or SA (Table 4).. In fact the mean LBP accuracy of the KEG had almost doubled, increasing from 6.5AccP±6.3AccP to 11.7AccP±3.7Accp (Table 7). LBP and SA testing procedures had an Intra-class correlation coefficient of 0.693 and 0.516 respectively at the 95% confidence interval (Table 8). The pre and post-test passing coefficient of variation was 15% and 46% respectively, and for shooting 49% and 59% (Table 8).

Table 5. Anthropometry of subjects.

	Number	Age	Height (m)	Weight kg	BMI
Intervention Groups	1	20	1.71	58.8	20.11
	2	20	1.71	55.6	19.01
	3	24	1.75	92.07	30.06
	4	20	1.71	58.3	19.94
	5	18	1.75	58	18.94
	6	18	1.75	52.2	17.04
	7	22	1.77	64.7	20.65
	8	23	1.72	52.1	17.61
	9	25	1.62	55.9	21.30
	10	19	1.72	57.5	19.44
	11	21	1.71	56.8	19.42
	12	24	1.62	55.6	21.19
	13	32	1.82	93.7	28.29
Control Group	14	24	1.67	47.2	16.92
	15	25	1.67	56.6	20.29
	16	27	1.75	55.8	18.22
	17	19	1.71	64.3	21.99
	18	19	1.67	51.9	18.61
	19	18	1.79	72.2	22.53
	Means	22	1.72	61.01	20.61
	±SD	3.68	0.05	12.46	3.40

Table 6. Training Intervention Strength and Power Results.

Subject	[a]Plyometric Training Pre (mm)	[a]Plyometric Training Post (mm)	[b]Leg-Extension Weight Training Pre (kg)	[b]Leg-Extension Weight Training Post (kg)
1			59.5	67.5
2			47.5	52.5
3			85	95
4			47.5	52
5			60	67.5
6			50	55
7	252	252		
8	228	241		
9	288	271		
10	240	251		
11	315	326		
±SD	36.0	34.1	14.3	16.4
Mean	264.60	268.20	58.25	*64.92

Note: SD= Standard Deviation a) Plyometric score calculated as the highest Counter Movement Jump of three attempts. b) This represents the maximum weight the subject could lift at the 10-repetition range of the training intervention. * ($p < 0.05$) effect size d= 0.4335146.

Table 7. Results of One-way ANOVA multiple comparisons test.

Variable		Mean ± SD Pre	Mean ± SD Post	Multiple Comparison	Training Group (a)	Training Group (b)	Sig.
Passing Accuracy (AccP)	KEG	6.5 ± 6.3	11.7± 3.7	Passing Accuracy (AccP)	KEG	PG	0.536
						CG	0.010*
	PG	5.2 ± 4.0	9.4 ± 4.2		PG	KEG	0.536
						CG	0.107
	CG	4.5 ± 2.7	5.0 ± 2.1		CG	KEG	0.010*
						PG	0.107
Shooting Accuracy (AccP)	KEG	8.11 ± 4.16	9.83 ± 3.01	Shooting Accuracy (AccP)	KEG	PG	0.498
						CG	0.158
	PG	9.93 ± 5.84	7.67 ± 4.38		PG	KEG	0.498
						CG	0.757
	CG	7.43 ± 2.77	6.33 ± 1.53		CG	KEG	0.158
						PG	0.757

* Significant at $p<0.005$ Note: SD= Standard Deviation.

Table 8. Reliability parameters of the LBP and SA testing prodecdures.

Variable	Mean ± SD	ICC (95% CI)	CV (95% CI)
Passing		0.693	
Shooting		0.516	
Passing Pre	5.41 ± 4.39		15%
Passing Post	8.59 ± 4.40		46%
Shooting Pre	8.96 ± 4.33		49%
Shooting Post	7.96 ± 3.27		59%

Note: SD= Standard Deviation; ICC= Intra-class correlation coefficient; CV= Coefficient of variation; 95% CI= 95% confidence interval.

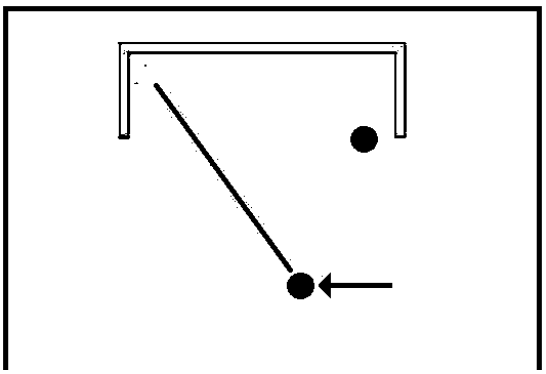
DISCUSSION

This study's results suggest that LBP accuracy is improved by Knee extensor strength in female footballers of a semi-professional standard, but not SA. Furthermore, that PT does not have a significant effect on either LBP or SA despite improving knee-extensor power.

The research's finding - that the Leg-extension strength training protocol significantly improved knee extensor strength is backed by the large quantities of accepted S&C science. The fact that this study found a significant improvement in LBP performance as a result of that seems to corroborate the papers of [35,9] indicating that strength training improves kicking velocity, with said papers expressing the importance of the knee extensors in that sports skill. Physiologically, the reasons for said improvement cannot be reported by this study. However the suggestion, based on the structure of the training protocol (rep range, set count, total intervention duration, outcome), is that some degree of muscle hypertrophy occurred, and percentage of myosin – heavy chain type IIa muscle

fibre increased, increased muscle fibre angle of pennation and increased radiological density [35,18]. Furthermore, it has been well reported that despite the difficulties and controversies in accurately recorded neurological data on muscle performance, and attributing those changes to strength increases, improved strength (especially in the first three weeks) will also in some part be due to neurological improvements; changes in intra-muscular co-ordination, adaptations in agonist muscle activation and enhanced firing frequency [35,18]. Moreover the mechanical effect of the physiological knee extensor improvements, is the ability to produce higher velocities of the distal limb at foot to ball contact, and thus achieve greater ball velocity. Although no other studies were found in the literature review on LBP accuracy for comparison, these findings do suggest a relationship between a female footballers maximum capacity for kicking velocity and LBP accuracy by way of being afforded the option of kicking at a lower more 'controllable' percentage of their maximum. The reason, clarified statistically in this study by the correlation between the subjects increase in pre and post intervention leg extension strength and LBP accuracy scores, 58.25kg±14.27kg to 64.91kg±16.35kg and 6.5AccP±6.3AccP to 11.7AccP±3.7Accp respectively. [26,44] Corroborates this by showing how subjects with insufficient ability to apply high velocities on the ball while maintaining accuracy prioritising accuracy. Reducing their kicking velocity i.e. the percentage of the maximum kicking velocity, further suggesting a relationship between the two. Interestingly, this significant increase in knee extensor strength didn't produce significant improvements in SA as hypothesised. This could be the down to the greater difficulty in controlling the testing procedure and the greater number of variable foot to ball contact positions involved – stemming from the wider trajectory angles the ball can travel at higher velocities while still remaining 'on target' in comparison to a LBP (Figure 6).

Figure 6. Illustrated example of the possible flight trajectory of a shot into an 11aside goal.



http://www.waterpoloplanet.com/vertical-to-horizontal-shots/

This angle is afforded to the subject by the 3.42m horizontal width of the goal from centre point to one goal post (Figure 4). Whereas the Five square grid scoring zone for the LBP test width is 2.5m, furthermore the distance to the target is an added 14.5m, reducing the trajectory angles that keeps the ball on target further. [22,23,24,27,34] Studies have shown the importance of ball contact on kicking performance. Furthermore [22,23,24,25,34] also found other important factors in kicking performance, those being (but not exclusively) position of hip, trunk and stabilising leg, factors which sensitivity to affecting the performance outcome could be increased with the wider ball trajectory angles of shooting. SA, even from 16.5m out - a distance [4] found to be enough to notice a deteriorated performance in comparison to men, appears to still be a skill with wide and varied enough technical parameters to be more robust to the effects of maximum kicking velocity improvements than LBP.

The PG, increased their mean power scores (jump performance), 264.60mm±36mm to 268.20mm±34.1mm, and also although improving their performance in LBP, 5.2AccP±4.0AccP to 9.4AccP±4.2AccP, it was not significant at the $p<0.05$ level ($p=0.10$). There was no improvement in the PG shooting performance. The significance at the 90% confidence interval instead of the papers 95% required margin could be attributed to the PG reduced group size of 6 to 5 or a more intricate problem with the PT protocol. [8,38,23] Have all managed to elicit improvements in power

via both VJ and or CMJ performance, with either a training period of 6 or 12 weeks, also using a variation of high intensity and low intensity plyometric exercises [39]. Therefore this PT protocols failing to elicit a statistically significant improvement at the $p<0.05$ was probably not due to the exercise modality chosen, but perhaps more based on the execution of those exercises by the subjects. Meaning that although instructed in the correct method of execution by an S&C coach during every session, perhaps the intangibles like subject motivation, or movement characteristics like biomechanical proficiency in those plyometric exercises, and time available to the S&C coach to correct an individuals improper technique where factors in limiting physiological responses to the training. In terms of SA, these factors were probably compounded by the same increased variability of foot to ball contact angles in shooting mentioned previously. Putting those intangibles to one side, the data as it stands is inconclusive in supporting a hypothesised link between improved power and accuracy in those specific skills.

Beyond that, there is a more obvious problem with the study design that could have contributed to the above lack of physiological response in the PG. This being that, due to the limitation in the pool of available players for the research, it was not possible to exclude subjects on the grounds of their level of experience with the PT protocol, whether to reduce learning effect, yield more consistency in execution, or allow for a greater applicability to the elite level of the sport. This lack of subject exclusion power was also a mitigating factor in being able to analyse the LBP and SA in the context of different player playing positions.

This paper's aim was to explore the effects of two different types of strength training on LBP and SA, as a first step in understanding the technical discrepancies in passing and shooting found in [4,6] and then begin a process of rectifying said discrepancy through enhancing the practice of S&C of female footballers and thusly their on field performance. Therefore future studies should focus on football performance specific parameters beyond accuracy, i.e. quality. Therefore, LBP would be

assessed for trajectory (height and flight path) and accuracy and shooting for ball velocity and accuracy (with preferred and non preferred leg) – the combination of these being critical in beating a goalkeeper and a defensive line respectively. Also known as the successful execution of said skill in a competitive match scenario. One further aspect of competitive match play that could be investigated is the role of muscle fatigue in all forms of passing and SA, and whether or not discrepancies exist between genders.

In summary, this paper found that the only significant effect was the effect that Leg extension strength training had on LBP accuracy. However, with a lager pool of subjects (using multiple teams), plus adjustments to the study and intervention designs alluded to in the above discussion, it is conceivable that more significant effects to the performance skills of LBP and shooting could be found in female footballers in future studies. Finally it seems inevitable that a parallel study using male subjects would also be meaningful and add further context to the results of any female focused research.

PRACTICAL APPLICATIONS

This is very limited, however it can be suggested that S&C coaches seeking to improve players LBP accuracy without taking time away from other tactical and technical work, consider implementing knee extensor strength training protocols in their adult female footballers, however at this stage no certainty can be given as to which strength training protocol would be most efficient in doing so. Furthermore, the study suggests that the chosen protocol can still potentially yield improvement if performed during the competitive season (with non regular first team squad players) and in conjunction with the athlete's regular football metabolic condition drills, tactical and technical football coaching sessions.

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More than 45 references were needed because this research has a very theoretical basis. Thus requiring large amounts of scientific literature to explain it's rational, and create a researchable framework that would yield meaningful results.

Appendix

Consent form

Name of Participant: _____

Title of the project: _____

Main investigator and contact details: _____

Members of the research team:

1. I agree to take part in the above research. I have read the Participant Information Sheet which is attached to this form. I understand what my role will be in this research, and all my questions have been answered to my satisfaction.
2. I understand that I am free to withdraw from the research at any time, for any reason and without prejudice.
3. I have been informed that the confidentiality of the information I provide will be safeguarded.
4. I am free to ask any questions at any time before and during the study.
5. I have been provided with a copy of this form and the Participant Information Sheet.

Data Protection: I agree to the University processing personal data which I have supplied. I agree to the processing of such data for any purposes connected with the Research Project as outlined to me.

Name of participant (print)……..

Signed……..…… Date…….....

If you wish to withdraw from the research, please complete the form below and return to the main investigator named above.

Title of Project: _____

I WISH TO WITHDRAW FROM THIS STUDY

Name:_____

Signed: _____ Date: _____

SEATED LEG EXTENSION COHORT

Subject

Name:

Age:

Height:

Weight:

BMI:

Playing Position:

Number of years playing competitive 11 aside football:

Exercise Working Set Load

Week 1:

Week 6:

Technique – Three seconds on downward phase, One second on the upward phase.

(Preformed 2x a week for 6 weeks)

Warm Up:

3 warm up sets @ 60%, 70% & 85% of working weight.

Exercise:

3 working sets of 10 reps, and 2.45min rest between sets – Lifting as heavy as is possible to sustain over 3 sets of 10 reps.

Cool Down:

3minutes of aerobic pace treadmill running or cycling, followed by 1 minute of stretching of static stretching of Quadricep muscle.

SEATED LEG EXTENSION COHORT

Subject

Name:

Age:

Height:

Weight:

BMI:

Playing Position:

Number of years playing competitive 11 aside football:

Exercise Working Set Load

Week 1:

Week 6:

Technique – Three seconds on downward phase, One second on the upward phase.

(Preformed 2x a week for 6 weeks)

Warm Up:

3 warm up sets @ 60%, 70% & 85% of working weight.

Exercise:

3 working sets of 10 reps, and 2.45min rest between sets – Lifting as heavy as is possible to sustain over 3 sets of 10 reps.

Cool Down:

3minutes of aerobic pace treadmill running or cycling, followed by 1 minute of stretching of static stretching of Quadricep muscle.

Plyometrics COHORT

Subject

Name:

Age:

Height:

Weight:

BMI:

Playing Position:

Number of years playing competitive 11 aside football:

Counter Movement Jump Height

Week 1:

Week 6:

Warm Up, Exercise & Cool Down Protocols to be carried out by Head of S&C at Swansea City Ladies Football Club.

Exercise Routine To be done 2x a week, for 6 weeks.

Plyometric Exercise Routine

Plyometric Training Group; A trained S&C coach will give specific instructions and demonstrations of each plyometric exercise before the first session. The plyometric training takes place after the warm-up, 2 days a week for 6 weeks (12 sessions distributed on Wednesday and Friday, with both supervised by the same coach. Each plyometric session will take 20-30minutes to perform, and the training regimen will be based on 2 different exercises, always coming after exercises specific plyometric warm up protocol:

- **Wednesday:** ***Warm up set*** - Series of 5 jumps over hurdles of 30cm height spaced apart at 45cm intervals with a rest of 30 seconds after 5 jumps and 4 minutes after 20 jumps. ***Working sets*** - 12 Bounds for height, 1min rest x 2, 12 bounds for distance, 1min rest x 2 (4min rest between the two exercises)
- **Friday:** ***Warm up set*** - Series of 5 bilateral Depth Jumps (DJ) off stands of 25cm onto stand of 50cm with a rest of 45sec after 5 jumps and 5 minutes after 20 jumps. ***Working sets*** – 5 unilateral DJ off stand of 15cm onto stand of 25cm, 2min rest x 2, 8 bilateral DJ off stand of 50cm onto stand of 75cm (if not achievable than any height above the drop off height), 1.30min rest x 2 (5min rest between the two exercises)

Training sessions will be carried out on a natural grass surface. **After 3 weeks, the number of jumps increased via an extra set on each working set exercise on Wednesday and Friday**. After 6 weeks, the total number of jumps will be 795. Intensity in terms of height/length and speed will always be maximal. During the jumps over hurdles, Bounds and DJ, subjects will be instructed to perform a free knee flexion position during the counter movement phase to ensure an individually and preferred chosen knee flexion angle to achieve the optimal jumping height. Technical proficiency of jumps will be monitored throughout, and quantity will be sacrificed for quality wherever necessary and reps completed will be noted beside the athlete's name. In all the exercises, players will be asked to minimize ground contact, psychologically aiming to perform the action as quickly as possible

Participation Information Sheet

Section A - The Research Project

- *Title of project?*

  'Comparing the effects of two different types of strength training on technical ball striking accuracy'

- *Purpose and value of study?*

  The study is designed to attempt to answer whether a strength training program of either lower body plyometric strength training or isolated knee extension strength training performed twice a week for 6 weeks would significantly effect a female soccer players accuracy when striking a football for a long ball pass and or shot towards goal and if so which one more so?

- *Invitation to participate?*

  For this research project I will be requiring 18 subjects, 3 subjects from each football playing position. And thus on behalf of myself and St Mary's University I would like to graciously ask for your participation as one of these subjects.

- *Who is organising the research?*

  The project while be independently organised by myself (Alpha Cauwenbergh), with logistical assistance for data collecting being provided by the Swansea City Laddies FC and Jack Spillets (Lead Strength and Conditioning Coach)

- *What will happen to the results of the study?*

  The results of the study will be used only for analysis within this research and for assessment from selected members of the St Mary's university faculty. There is also a chance that the research and its findings will be published in a scientific journal. If that occurs participants will be notified.

- *Source of funding for the research?*

  This study and all equipment used outside of those provided by the football club will be funded completely by myself where necessary.

- Contact for further information?
  For further information please email me at acauwenbergh@yahoo.co.uk

Section B - Your Participation in the Research Project

- *Why you have been invited to take part?*

The reason you have been chosen as a subject for this research is because you fit the essential criteria; As in you are over 21, injury free, a goalkeeper, center back, full back, midfielder, wide midfielders, or a forward. With a minimum of 5 years experience playing competitive 11 aside football, training on average 1 and a half hours a week.

- *Whether you can refuse to take part or withdraw from the project at any time, and how?*

  Of course you can decline this invitation as well as withdraw from the study at any point, by simply emailing me your wish to do so and the reasons for your withdrawal.

- *What will happen if you agree to take part (brief description of procedures/tests)?*

  If you agree to take part, the next step is filling in the consent form and returning it to myself. After which you will be invited to attend the first data collection session. You and the other subjects will be asked to take part in a 50min (total) testing session at the clubs training ground with each participants testing taking approximately 30min excluding a 20min warm up protocol. The testing protocol will consist of you having to strike a ball towards an 11 aside goal utilising both a shooting and 'long ball' passing techniques. This will be measured in terms of accuracy and speed at which the ball travelled. After this stage is completed you will be randomly assigned to group 1, group 2 or group 3, two of which having a prescribed training regime to follow twice a week (plyometrics or knee extension strength training) for 6 weeks, and the third a control group, who will continue with their normal training regime. After this period a second testing session is performed, with the results of this second session compared to the first and any changes in scores assessed and evaluated for significance and practical meaning and application.

- *Whether there are any risks involved (e.g. side effects) and if so, what will be done to ensure your wellbeing/safety?*

  As this research project is within the realms of your usual football and physical conditioning regimes the risks are greatly reduced. However all risks can never be completely eliminated, and some of the potential risks to taking part in the study are as follows; muscular/ligament/tendon strains during ball striking actions, and or during strength training exercises, trips and falls, illness coming from outdoor training in winter months, injuries resulting in miss use of equipment or from faulty equipment. In order to minimise the risk of these occurring; a thorough warm up and cool down routines will be prescribed and implemented before and after all testing and exercise sessions, the on field plyometric session will be monitored by the clubs certified strength and conditioning coach, self reported gym sessions being created by a qualified exercise professional with the option of bespoke monitoring from in house gym staff and Level 3 qualified Personal Trainers, subjects will be advised on appropriate footwear and attire for training outdoors in cold, or wet weather and all equipment will be checked before and after outdoor sessions, with gym equipment being required to have passed the weekly maintenance checks performed by staff.

- *Agreement to participate in this research should not compromise your legal rights if something goes wrong?*

  Participation in this study will not infringe on your legal rights if something were to go wrong.

- *Whether there are any special precautions you must take before, during or after taking part in the study?*

Furthermore to the mentioned warm up and cool down regimes, the other special precaution to be taken before testing is for the subject to not have performed any lower limb strength training 48hrs before testing, and no high intensity metabolic conditioning (cardio) 24hrs before testing. Finally testing should be performed before the start of the subjects regular technical and tactical training session. With them being free to join the normal session once her participation in testing is completed.

- *What will happen to any information/data/samples that are collected from you?*

  Any information collected by me during the course of the study will be kept exclusively by me and used solely for the completion of this research project.

- *Whether there are any benefits from taking part?*

  The potential benefits to taking part in this project range from the training knowledge and physical improvements that can come adhering to a professional strength training program for 6 weeks, to the chance of having those improvements transfer over to your footballing performance allowing for higher levels of sporting excellence.

- *How much time you will need to give up to take part in the project?*

  To participate in this project, the Plyometric Group and Knee Extension Group participants will be required to commit approximately 7hrs and 20mins to the study, 1hr and 20min total for the two testing sessions, and 6 hours over a 6 week period for the training interventions. The Control Group participants will only need to commit 1hr and 20mins total for the two testing sessions.

- *How your participation in the project will be kept confidential?*

  Your participation in this project will be kept strictly between the club and myself, with no names or personal contact details being mentioned within the final written study.

YOU WILL BE GIVEN A COPY OF THIS FORM TO KEEP TOGETHER WITH A COPY OF YOUR CONSENT FORM

Regards,

Alpha Cauwenbergh

St Mary's University,
Waldegrave Road,
Strawberry Hill,
Twickenham,
London TW1 4SX

T: 020 8240 4000

St Mary's University Twickenham London

St Mary's University

Ethics Sub-Committee

Application for Ethical Approval (Research)

This form must be completed by any undergraduate or postgraduate student, or member of staff at St Mary's University, who is undertaking research involving contact with, or observation of, human participants.

Undergraduate and postgraduate students should have the form signed by their supervisor, and forwarded to the School Ethics Sub-Committee representative. Staff applications should be forwarded directly to the School Ethics Sub-Committee representative. All supporting documents should be merged into one PDF (in order of the checklist) and clearly entitled with your **Full Name, School, Supervisor.**

Please note that for all undergraduate research projects the supervisor is considered to be the Principal Investigator for the study.

If the proposal has been submitted for approval to an external, properly constituted ethics committee (e.g. NHS Ethics), then please submit a copy of the application and approval letter to the Secretary of the Ethics Sub-Committee. Please note that you will also be required to complete the St Mary's Application for Ethical Approval.

Before completing this form:

- Please refer to the **University's Ethical Guidelines**. As the researcher/ supervisor, you are responsible for exercising appropriate professional judgment in this review.
- Please refer to the Ethical Application System (Three Tiers) information sheet.
- Please refer to the Frequently Asked Questions and Commonly Made Mistakes sheet.
- If you are conducting research with children or young people, please ensure that you read the **Guidelines for Conducting Research with Children or Young People**, and answer the below questions with reference to the guidelines.

Please note:

In line with University Academic Regulations the signed completed Ethics Form must be included as an appendix to the final research project.

If you have any queries when completing this document, please consult your supervisor (for students) or School Ethics Sub-Committee representative (for staff).

St Mary's Ethics Application Checklist

The checklist below will help you to ensure that all the supporting documents are submitted with your ethics application form. The supporting documents are necessary for the Ethics Sub-Committee to be able to review and approve your application.

Please note, if the appropriate documents are not submitted with the application form then the application will be returned directly to the applicant and may need to be re-submitted at a later date.

	Enclosed? (delete as appropriate)		Version No
Document	Yes	Not applicable	
1. Application Form	Mandatory		
2. Risk Assessment Form			
3. Participant Invitation Letter		Not applicable	
4. Participant Information Sheet	Mandatory		
5. Participant Consent Form	Mandatory		
6. Parental Consent Form			
7. Participant Recruitment Material - e.g. copies of Posters, newspaper adverts, website, emails			
8. Letter from host organisation (granting permission to conduct the study on the premises)	Yes		
9. Research instrument, e.g. validated questionnaire, survey, interview schedule			
10. DBS **(to be sent separately)**			
11. Other Research Ethics Committee application (e.g. NHS REC form)			
12. Certificates of training (required if storing human tissue)			

I can confirm that all relevant documents are included in order of the list and in one PDF document (any DBS check to be sent separately) named in the following format: ***Full Name, School, Supervisor.***

Signature of Applicant: Alpha Maurice Cidade Cauwenbergh

Signature of Supervisor:

St Mary's University Twickenham London

Ethics Application Form

1) Name of proposer(s)	Alpha Maurice Cidade Cauwenbergh
2) St Mary's email address	145486@live.stmarys.ac.uk
3) Name of supervisor	Giuseppe Cimadoro

4) Title of project Comparing the effects of two different types of strength training on technical ball striking accuracy

5) School or service	
6) Programme (whether undergraduate, postgraduate taught or postgraduate research)	Postgraduate research

7) Type of activity/research (staff/undergraduate student/postgraduate student)	Postgraduate student

8) Confidentiality	
Will all information remain confidential in line with the Data Protection Act 1998?	YES

9) Consent	
Will written informed consent be obtained from all participants/participants' representatives?	YES/NO

10)Pre-approved protocol	
Has the protocol been approved by the Ethics Sub-Committee under a generic application?	YES/NO/Not applicable Date of approval:

11)Approval from another Ethics Committee	
a) Will the research require approval by an ethics committee external to St Mary's University?	YES/NO/Not applicable
b) Are you working with persons under 18 years of age or vulnerable adults?	YES/ NO

12) Identifiable risks	
a) Is there significant potential for physical or psychological discomfort, harm, stress or	YES/NO

burden to participants?	
b) Are participants over 65 years of age?	YES/NO
c) Do participants have limited ability to give voluntary consent? This could include cognitively impaired persons, prisoners, persons with a chronic physical or mental condition, or those who live in or are connected to an institutional environment.	YES/NO
d) Are any invasive techniques involved? And/or the collection of body fluids or tissue?	YES/NO
e) Is an extensive degree of exercise or physical exertion involved?	YES/NO
f) Is there manipulation of cognitive or affective human responses which could cause stress or anxiety?	YES/NO
g) Are drugs or other substances (including liquid and food additives) to be administered?	YES/NO
h) Will deception of participants be used in a way which might cause distress, or might reasonably affect their willingness to participate in the research? For example, misleading participants on the purpose of the research, by giving them false information.	YES/NO
i) Will highly personal, intimate or other private and confidential information be sought? For example sexual preferences.	YES/NO
j) Will payment be made to participants? This can include costs for expenses or time.	YES/NO If yes, please provide details
k) Could the relationship between the	YES/ NO

researcher/ supervisor and the participant be such that a participant might feel pressurised to take part?	
l) Are you working under the remit of the Human Tissue Act 2004?	YES/ NO

13)Proposed start and completion date
Please indicate: • When the study is due to commence. • Timetable for data collection. • The expected date of completion. Please ensure that your start date is at least 3 weeks after the submission deadline for the Ethics Sub-Committee meeting.

14)Sponsors/Collaborators
Please give names and details of sponsors or collaborators on the project. This does not include your supervisor(s) or St Mary's University. • Sponsor: An individual or organisation who provides financial resources or some other support for a project. • Collaborator: An individual or organisation who works on the project as a recognised contributor by providing advice, data or another form of support.

15. Other Research Ethics Committee Approval
• Please indicate whether additional approval is required or has already been

obtained (e.g. the NHS Research Ethics Committee).

- Please also note which code of practice / professional body you have consulted for your project.
- Whether approval has previously been given for any element of this research by the University Ethics Sub-Committee.

16. Purpose of the study

In lay language, please provide a brief introduction to the background and rationale for your study.

- Be clear about the concepts / factors / performances you will measure / assess/ observe and (if applicable), the context within which this will be done.
- Please state if there are likely to be any direct benefits, e.g. to participants, other groups or organisations.

17. Study Design/Methodology

In lay language, please provide details of:

a) The design of the study (qualitative/quantitative questionnaires etc.)
b) The proposed methods of data collection (what you will do, how you will do this and the nature of tests).
c) You should also include details regarding the requirement of the participant i.e. the extent of their commitment and the length of time they will be required to attend testing.
d) Please include details of where the testing will take place.
e) Please state whether the materials/procedures you are using are original, or the intellectual property of a third party. If the materials/procedures are original, please describe any pre-testing you have done or will do to ensure that they are effective.

18. Participants

Please mention:

a) The number of participants you are recruiting and why. For example, because of their specific age or sex.
b) How they will be recruited and chosen.
c) The inclusion/exclusion criteria.
d) For internet studies please clarify how you will verify the age of the participants.
e) If the research is taking place in a school or organisation then please include their written agreement for the research to be undertaken.

19. Consent

If you have any exclusion criteria, please ensure that your Consent Form and Participant Information Sheet clearly makes participants aware that their data may or may not be used.

a) Are there any incentives/pressures which may make it difficult for participants to refuse to take part? If so, explain and clarify why this needs to be done

b) Will any of the participants be from any of the following groups?

- Children under 18
- Participants with learning disabilities
- Participants suffering from dementia
- Other vulnerable groups.

c) If any of the above apply, does the researcher/investigator hold a current DBS certificate? A copy of the DBS must be supplied **separately from** the application.

d) How will consent be obtained? This includes consent from all necessary persons i.e. participants and parents.

20. Risks and benefits of research/ activity

a) Are there any potential risks or adverse effects (e.g. injury, pain, discomfort, distress, changes to lifestyle) associated with this study? If so please provide details, including information on how these will be minimised.

b) Please explain where the risks / effects may arise from (and why), so that it is clear why the risks / effects will be difficult to completely eliminate or minimise.

c) Does the study involve any invasive procedures? If so, please confirm that the researchers or collaborators have appropriate training and are competent to deliver these procedures. Please note that invasive procedures also include the use of deceptive procedures in order to obtain information.

d) Will individual/group interviews/questionnaires include anything that may be sensitive or upsetting? If so, please clarify why this information is necessary (and if applicable, any prior use of the questionnaire/interview).

e) Please describe how you would deal with any adverse reactions participants might experience. Discuss any adverse reaction that might occur and the actions that will be taken in response by you, your supervisor or some third party (explain why a third party is being used for this purpose).

f) Are there any benefits to the participant or for the organisation taking part in the research (e.g. gain knowledge of their fitness)?

21. Confidentiality, privacy and data protection

a) What steps will be taken to ensure participants' confidentiality?

- Please describe how data, particularly personal information, will be stored (all electronic data must be stored on St Mary's University servers).
- Consider how you will identify participants who request their data be withdrawn, such that you can still maintain the confidentiality of theirs and others' data.

b) Describe how you will manage data using a data a management plan.

- You should show how you plan to store the data securely and select the data that will be made publically available once the project has ended.
- You should also show how you will take account of the relevant legislation including that relating data protection, freedom of information and intellectual property.

c) Who will have access to the data? Please identify all persons who will have access to the data (normally yourself and your supervisor).

d) Will the data results include information which may identify people or places?

• Explain what information will be identifiable. • Whether the persons or places (e.g. organisations) are aware of this. • Consent forms should state what information will be identifiable and any likely outputs which will use the information e.g. dissertations, theses and any future publications/presentations.

22. Feedback to participants
Please give details of how feedback will be given to participants: • As a minimum, it would normally be expected for feedback to be offered to participants in an acceptable to format, e.g. a summary of findings appropriately written. • Please state whether you intend to provide feedback to any other individual(s) or organisation(s) and what form this would take.

The proposer recognises their responsibility in carrying out the project in accordance with the University's Ethical Guidelines and will ensure that any person(s) assisting in the research/ teaching are also bound by these. The Ethics Sub-Committee must be notified of, and approve, any deviation from the information provided on this form.

Signature of Proposer(s)	Date:
Signature of Supervisor (for student research projects)	Date:

St Mary's University Twickenham London

Approval Sheet

Name of applicant: Name of supervisor: Programme of study: Title of project:

Supervisors, please complete section 1 or 2. If approved at level 1, please forward a copy of this Approval Sheet to the School Ethics Representative for their records.

SECTION 1 Approved at Level 1 Signature of supervisor (for student applications)..... Date.....
SECTION 2 Refer to School Ethics Representative for consideration at Level 2 or Level 3 Signature of supervisor..... Date.....
SECTION 3 To be completed by School Ethics Representative Approved at Level 2 Signature of School Ethics Representative..... Date.....

SECTION 4 To be completed by School Ethics Representative. Level 3 consideration required byt the Ethics Sub-Committee (including all staff research involving human participants) Signature of School Ethics Representative..... Date..... Level 3 approval – confirmation will be via correspondence from the Ethics Sub-Committee